Characteristics of Silicon Solar Cells used as Fission Fragment Detectors ◇

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The study of the nuclear structure in the second minimum of the potential energy surface in actindes requires an efficient trigger on delayed fission events [1]. Commercially available silicon solar cells offer an attractive cost effective solution to this demand. In order to successfully apply solar cells in fission isomer studies, besides the ability to resolve the fission fragment mass distribution the time resolution has to be optimised in order to allow for an unambiguous identification of delayed fission events. For the intended use in the study of the 110 ns isomer in ^{237}Pu [2] a time resolution of approximately 20 ns is required.

Off-and online experiments were performed to characterise the performance of two different types of monocrystalline solar cells (ASE: TZZE4020 and TE16SF, $2 \times 4\,cm^2$). In the online measurements a pulsed α-beam ($\Delta t \simeq 200$ ns, $E_\alpha \simeq 24\,MeV$) was focused onto a thin ^{235}U target (U_2O_3 with $\sim 100\,\mu g/cm^2$ on C backing), inducing fission, to measure the time resolution for the fission fragments. The solar cells were placed at angles between 30° and 60° with respect to the beam ($\sim$4 cm distance from the target). The beam current was $\sim$1 nA, inducing a count rate of about 50 Hz in a single solar cell.

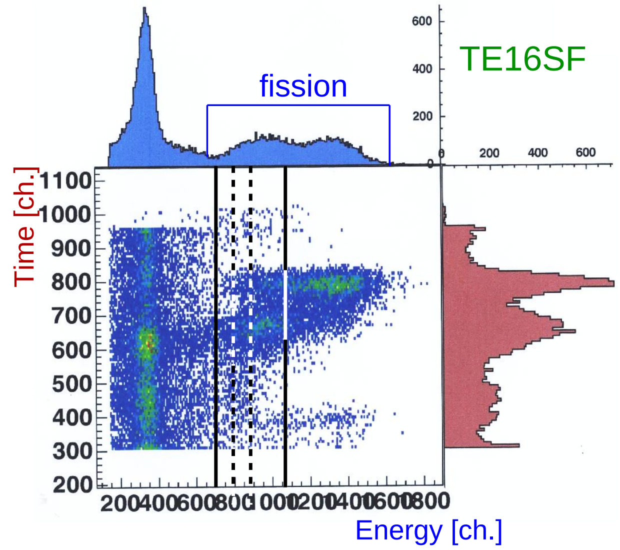

Fig. 1: Energy versus time spectrum for the ^{235}U(α,f) reaction.

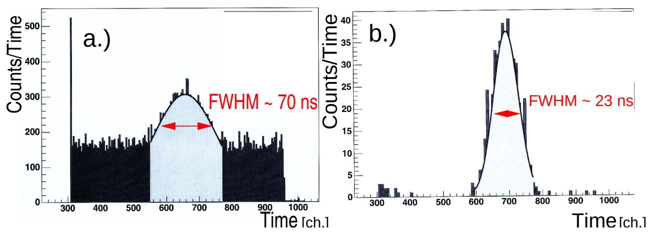

Fig. 2: Solar cell time spectra for fission fragments projected from Fig. 1. Part a.) shows the flight time distribution of the heavy fragments, part b.) the solar cell time resolution when gated on a narrow energy region (dashed lines) in Fig. 1.

Fig. 1 shows the energy-time correlation from signals detected by a TE16SF solar cell following ^{235}U(α,f). The strong background contribution at low energies results from scattered α-projectiles, while at higher energies the two fission fragments are clearly visible. Projecting onto the heavy fission fragment (as indicated by the solid lines) results in the time spectrum of Fig. 2 a.) The distribution with a width of $\sim$70 ns (FWHM) reflects the spread of fission fragment flight times. An estimate of the time resolution can be obtained by projecting only a narrow fraction of the fission fragment distribution as indicated by the dashed lines. This results in the time spectrum of Fig. 2 b.) exhibiting a time resolution of $\sim$23 ns.

The monocrystalline solar cells are covered with an anti-reflective layer of TiO_2. For the offline measurements this layer was etched off in a 10 % HF solution.The mass resolution angular dependency of two types of solar cells was measured, for both etched and non-etched cells. The solar cells were placed at $\sim$10 cm distance to a ^{252}Cf source and the angle of the source was varied from $\sim$20° to $\sim$90° around the solar cells. The results of these measurements are shown in Figure 3 [3].

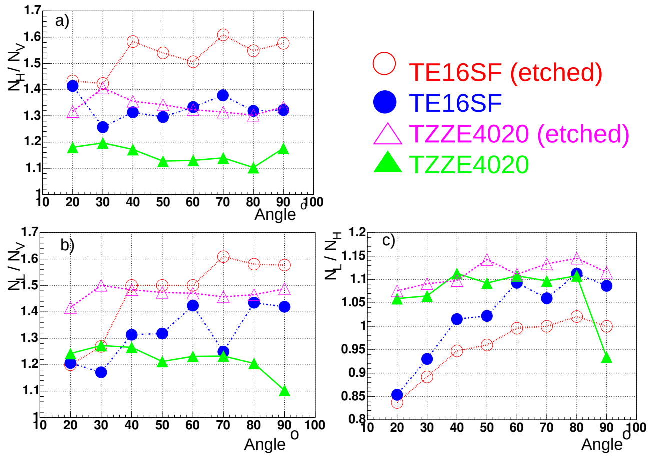

Fig. 3: Angular dependent response of two types of solar cells (each etched and non-etched) to a ^{252}Cf fission source. N_H (N_L) denotes the intensity of the heavy (light) fragment peak. N_V is the intensity in the valley of the mass distribution.

The comparison of the peak to valley ratios for the heavy and light-fragment mass peaks (N_H/N_V and N_L/N_V) of the ^{252}Cf fission fragment distribution consistently shows larger values for the etched cells. Furthermore, no pronounced angular dependency was observed. This indicates a rather thin anti reflective layer. However, whilst no significant angular dependency was found for the intensity ratio N_L/N_H for the TZZE4020 cells, in the case of the TE16SF cells an angular suppression of the high energetic (light fragment) mass peak intensity at small angles was observed (Fig. 3c). This may indicate an influence of the TiO_2 layer even after the etching procedure. The characteristics described above enable the use of silicon solar cells in the study of ^{237f}Pu [2].

References

[1] P.G. Thirolf, Habiliatition Thesis, LMU München (2003)
[2] T. Morgan *et al.*, this report p. 26
[3] C. Schürmann, Facharbeit (2004)

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